Technical Memorandum

TO: Jane Crowley, Town of Eastham
FROM: Liz Moran, EcoLogic LLC
RE: Updated data for the Nauset (Salt Pond)
DATE: December 17, 2018

At your request, we have updated our technical memorandum after reviewing the 2017 water quality data collected within the Eastham portion of the Nauset Harbor Embayment System. Updated metadata files and the plots of Sand Pond water quality conditions over time are included. The Towns of Eastham and Orleans are following the recommended adaptive management approach to wastewater management planning; namely, to continue monitoring and data analysis to improve our collective understanding of factors affecting the health of the watersheds and estuaries.

Regulatory Context

In 2012, the Massachusetts Department of Environmental Protection issued the nitrogen goals and loading thresholds for long-term restoration and protection of the Nauset Estuary[1]. The management goal for the Nauset Harbor estuary system is to expand eelgrass habitat by approximately 80 acres. Resource managers concluded that reducing nitrogen loading to a level that will enable an expansion of eelgrass will also improve the habitat for benthic organisms; animals including shellfish are more tolerant than eelgrass to elevated nitrogen and the associated algal abundance. The target nitrogen level was set at 0.45 mg/L considering the Nauset data along with work on other MEP systems. The target nitrogen concentration of 0.45 mg/L is adopted as a threshold for Salt Pond restoration as well.

Current Conditions and Trends

Multiple monitoring stations are established within the Nauset Harbor Embayment System, as show in Figure 1. The sampling program varied over the years; stations were removed from the program following the intensive surveys in 2003 and 2004. Monitoring was expanded in 2016 to include additional sites **(Table 1**). Three embayments: Salt Pond (site WMO38), Town Cove (site WMO27) and Mill Pond (site WM034) have consistently been part of the monitoring program.

[1] Howes, B., S. Kelley, J. S. Ramsey, E. Eichner, R. Saminy, D. Schlezinger, P. Detjens. 2012 (revised). Massachusetts Estuary Program Linked Watershed-Embayment Approach to Determine Critical Nitrogen Loading Thresholds for the Nauset Harbor Embayment System, Towns of Orleans and Eastham, Massachusetts. Massachusetts Department of Environmental Protection. Boston MA.
http://www.town.orleans.ma.us/sites/orleansma/files/file/file/nauset_mep_revised_draft.pdf

Table 1. Summary of metadata, water quality monitoring within the Nauset Harbor estuary system, 2003-2017

Year	Stations	Events	Frequency and Schedule	Parameters
2003	25 - 41 (41 is ocean)	6	Biweekly, June 4-Aug18	Secchi, salinity, DO, PO4, N series, POC, algal pigments, fecal coliform
2004	25-40 except 28,31,37	5	Biweekly, June22-Aug20	as 2003, dropped fecal coliform
2005	25,27,34,38	7	Biweekly, June13-Aug24	as 2004
2006	27,34,38	6	Biweekly, June29-Sept12	as 2004 (+total pigment, calculated)
2007	27 (4 events), 34,38	5	Biweekly, July5-Sept17	as 2006
2008	27,34,38	5	Biweekly, July7-Sept4	as 2006
2009	27,34,38	5	Biweekly, July13-Sept9	as 2006
2010	27, 34, 38	5	Biweekly, July15-Sept13	as 2006
2011	27,34,38	4	Biweekly July, once Aug & Sept (7/6 - 9/19)	as 2006
2012	27,34,38	5	Biweekly, 7/9-9/6	as 2006
2013	27,34,38	5	Biweekly, 7/11-9/10- no 34 last date	as 2006
2014	27,34,38	5	Biweekly, 7/16-9/11	as 2006
2015	27,34,38	5	Biweekly, 7/7-9/3	as 2006
2016	28,29,36,37,38,39	5	Biweekly, 7/7-9/7	as 2006
2017	25,26,27,28,29,30,31, 32,33,34,35,36,37,38, 39	5	Biweekly, 7/13 – 9/11	as 2006

Figure 1. Water quality monitoring stations in Nauset Harbor estuary system

Monitoring station WMO38 is located in Eastham's Salt Pond. Data from annual monitoring efforts were compiled to review status and trends of key metrics related to eutrophication: total N concentrations, water clarity (Secchi disk transparency), concentration of algal pigments, and dissolved oxygen status of the deep waters.

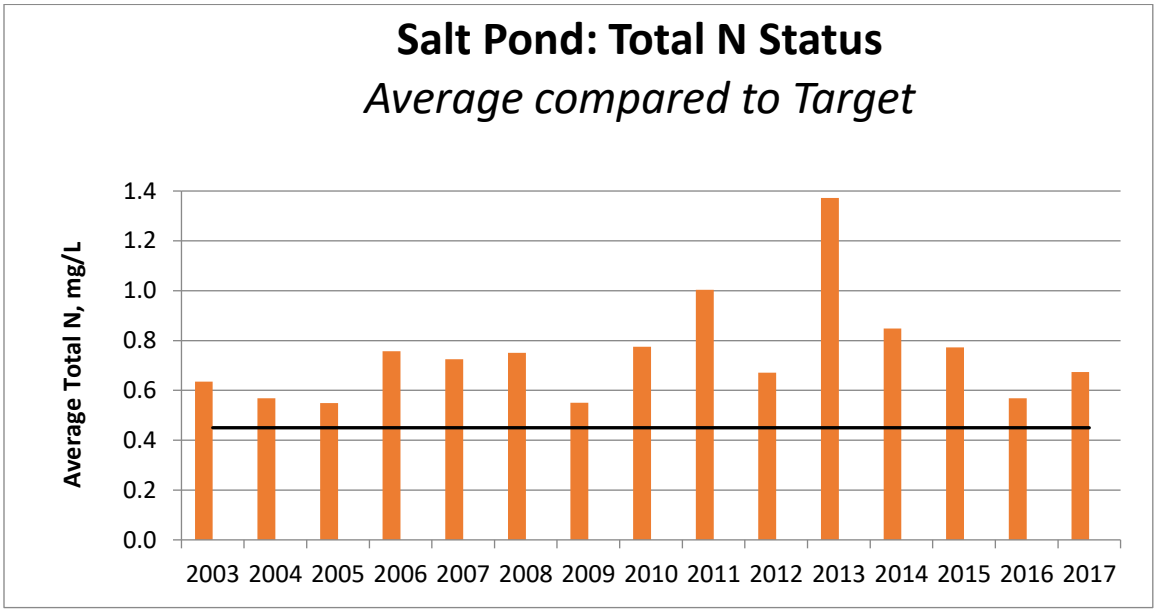

Figure 2. Summer average total N concentrations at Salt Pond station WMO38 compared to TMDL target, 0.45 mg/L total N

Note that the average total N (which includes organic and inorganic, dissolved and particulate fractions) is highly variable from year-to-year (**Figure 2**). The data plotted are the water column average values, which include samples from the surface and bottom waters as well as mid-depth samples in most years. Note also that all years of record exceed the threshold of 0.45 mg/L corresponding to a healthy ecosystem.

Nitrogen is the limiting nutrient for phytoplankton growth in this estuarine ecosystem, meaning that the abundance of phytoplankton is regulated by the supply of nitrogen. The elevated N concentrations in Salt Pond support abundant plankton growth. As shown in **Figure 3**, algal pigments (a measure of phytoplankton abundance) are also highly variable from year-to-year. Note the logarithmic scale of the graph; this is to accommodate the high concentrations measured during bloom conditions, defined as algal pigment concentrations greater than 30 µg/L. Blooms of harmful algae (e.g., red tide) have become common in regions of the Nauset Estuary, including Salt Pond.

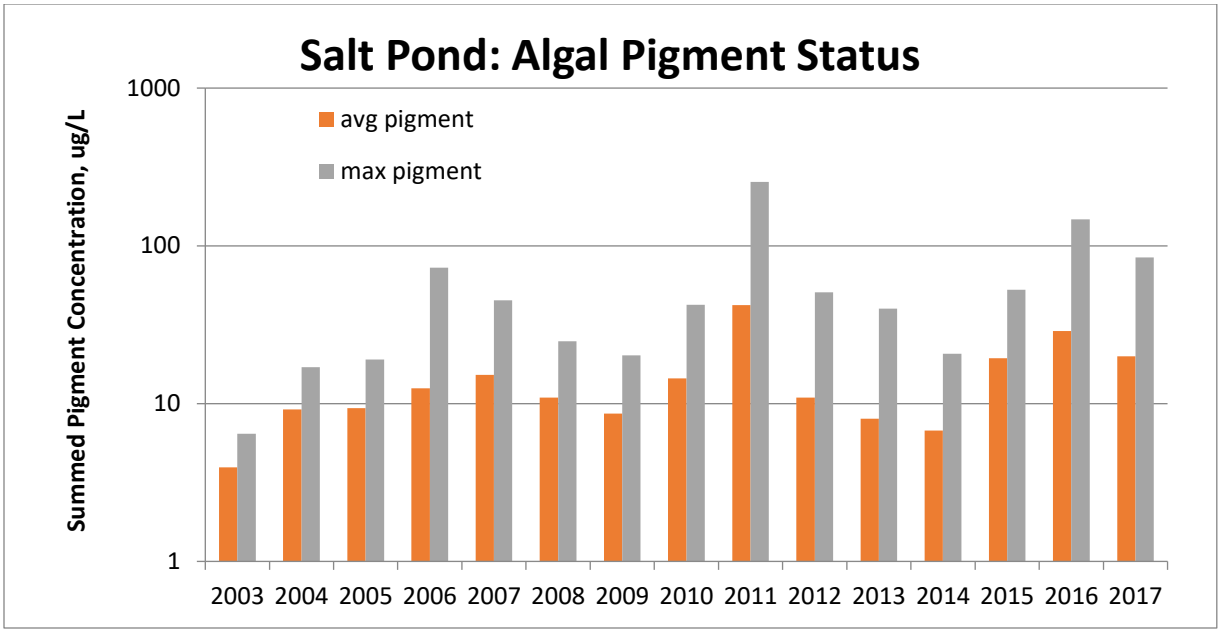

Figure 3. Average and maximum concentrations of algal pigments, Salt Pond station WMO38 (note bloom threshold is considered 30 µg/L.

Elevated algal pigment concentrations lead to diminished water clarity, affecting the aesthetic quality of the resource as well as limiting light penetration needed to support eelgrass. The average and minimum Secchi disk transparency of Salt Pond is displayed in **Figure 4**. Note that the pond depth is approximately 9.4 m (+/- 30 ft). A Secchi disk reading of 2 m or more is generally indicative of low phytoplankton abundance and clear water.

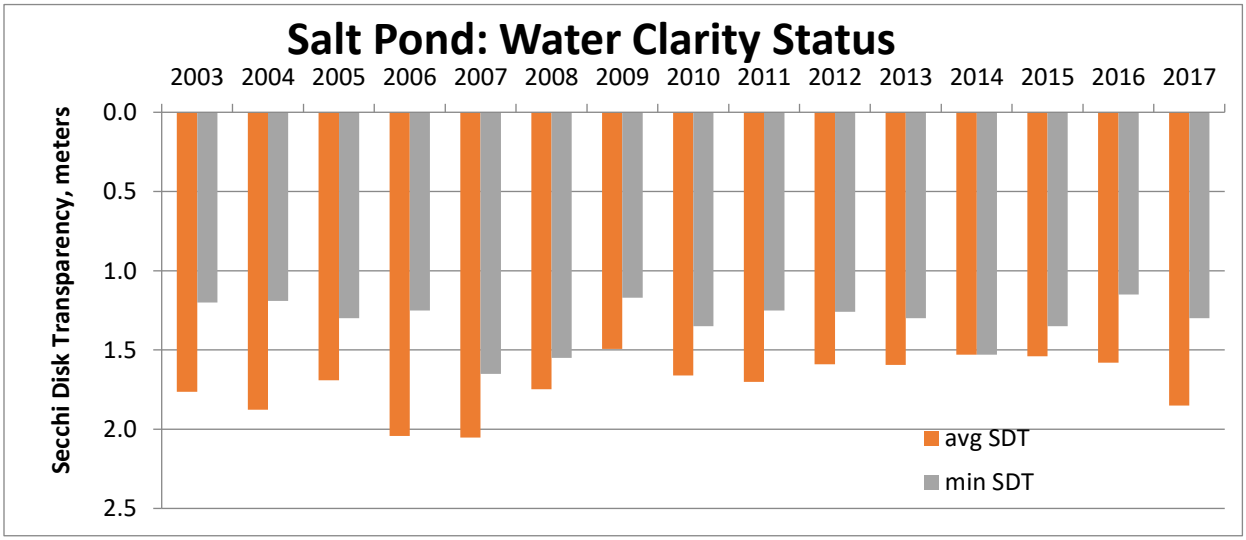

Figure 4. Average and minimum Secchi disk transparency (SDT), Salt Pond station WMO38 compared to a 2 m target water clarity.

The final important metric related to nitrogen enrichment is the dissolved oxygen status of the lower waters. As shown in Figure 5, the deep waters of Salt Pond are subject to hypoxia (low concentrations of dissolved oxygen, DO). This condition is a direct effect of the pond's depth; Salt Pond develops thermal stratification during the summer, isolating the deeper waters from the two sources of oxygen in the water: exchange with the atmosphere and photosynthesis. The average concentration of DO is less significant, however, than the minimum concentration. In Massachusetts, the ambient water quality standard for protection of aquatic life is set at 6.0 mg/L. The percentages included in Figure 5 refer to the percent of observations that do not meet this standard. The trend in deep water oxygen status of Salt Pond is clearly in decline.

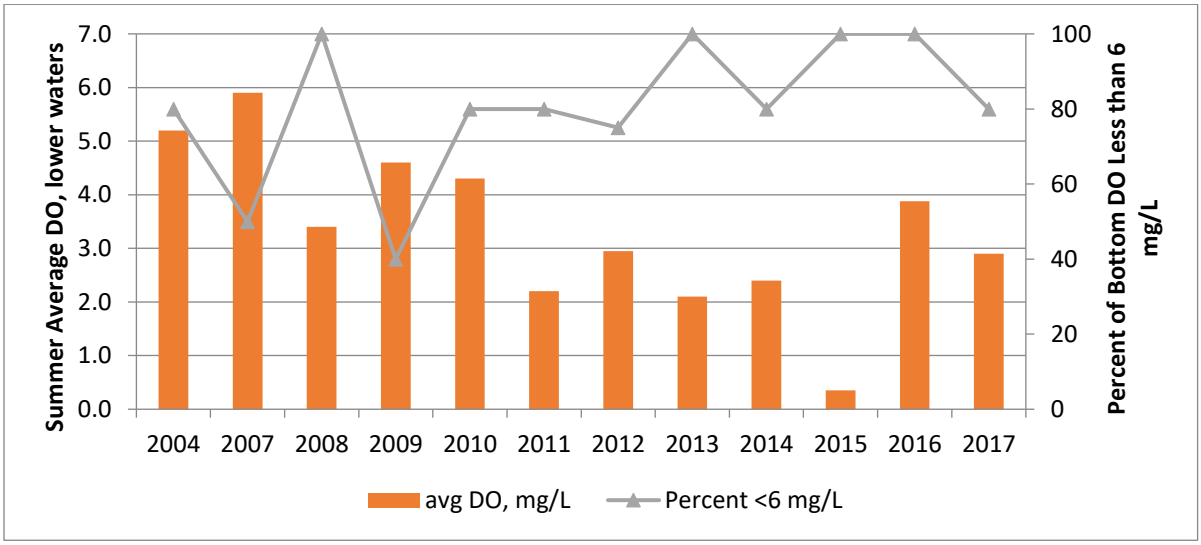

Figure 5. Average dissolved oxygen (DO) of Salt Pond station WMO38 lower waters, plus percent of observations below 6 mg/L, ambient water quality standard for aquatic life protection

Results of annual water quality monitoring of Eastham's Salt Pond indicate that the pond is enriched with nutrients (eutrophic). The concentrations of nitrogen (limiting nutrient for algal production) in Salt Pond are well above the threshold for a healthy estuarine ecosystem (0.45 mg/L total N).

As a consequence of the elevated N concentrations, Salt Pond supports abundant algal growth, with periodic bloom conditions. Blooms of red tide, *Alexandrium fundyense,* the alga linked to paralytic shellfish poisoning (PSP) have become a regular occurrence. According to a 2008 report by biologist Don Anderson of Woods Hole Oceanographic Institute, PSP occurred in Salt Pond in eight of 17 years (48 percent) from 1975 to 1991 and in 16 of the next 17 years (94 percent).[i2] The risk of harm from red tide may extend beyond Salt Pond if the algal cells are transported to other areas within the Nauset estuary system.

Algal blooms reduce the water clarity of Salt Pond, which in turn reduces habitat available for eelgrass as less light reaches the sediment surface. As algal cells die and settle to the bottom of the pond,

[2] http://seagrant.mit.edu/2ifbysea/issues/fall08/blooms.html

decomposition of the organic material depletes the supply of dissolved oxygen which further diminishes habitat quality. Under current conditions, the deep waters of Salt Pond routinely violate the state's ambient water quality standard for dissolved oxygen, in place to protect aquatic life.

The 2003 – 2017 SMAST monitoring data for Salt Pond indicate declining trends in water quality conditions. Nitrogen concentrations are increasing, along with algal pigment levels and bloom intensity. Water clarity has decreased. Deep water dissolved oxygen levels are also in decline. Without a continued focus on controlling external nitrogen loading, water quality conditions will not improve and are likely to continue to decline, with an increasing risk of harmful algal blooms.

The long-term water quality data sets have been extremely valuable for assessing current conditions and trends. Continued coordination with the Town of Orleans to ensure that the volunteer monitoring efforts are supported will be part of the overall adaptive management approach to assessing the health of the Nauset Harbor estuary system.